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(54) Cleaning vacuum processing chamber

(57) In a method for cleaning a vacuum process chamber of a dry etching apparatus, oxidative gas including rare gas is introduced into the vacuum process chamber and plasma is excited therein. Then, after the plasma oxidative gas is exhausted, fluoride gas is introduced into the vacuum processing chamber and plasma is excited therein.

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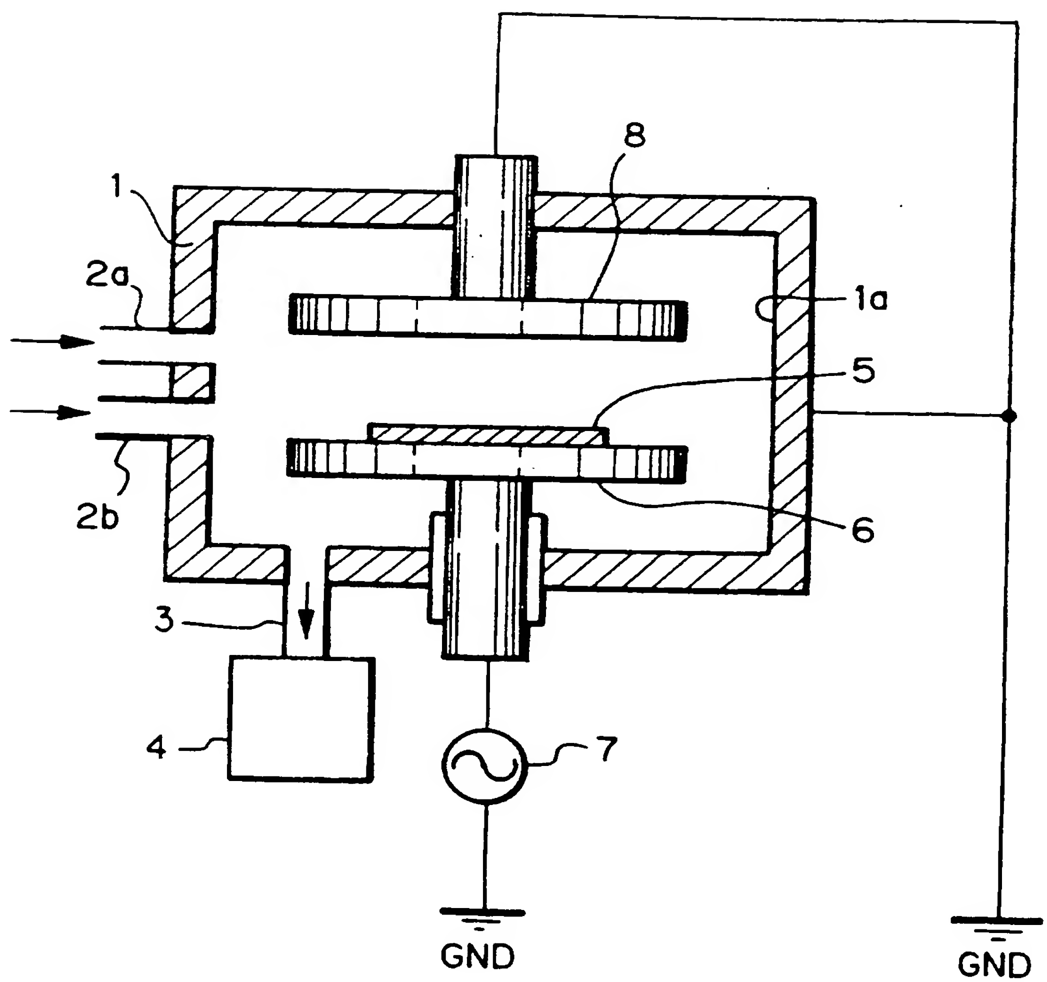
Fig. 1



METHOD FOR CLEANING VACUUM PROCESSING CHAMBER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method for cleaning a vacuum processing chamber of a dry etching apparatus for carrying out an etching process using bromide gas.

Description of the Related Art

A dry (plasma) etching apparatus has been broadly used in obtaining a fine structure of semiconductor devices. In a dry etching method, a silicon substrate having a polycrystalline silicon layer deposited thereon is located within a vacuum processing chamber, and then, a hydrogen bromide (HBr) gas is introduced into the vacuum processing chamber. Then, plasma is excited to etch the polycrystalline silicon layer. In this plasma etching, a residual reaction product such as silicon bromide (Si_xBr_y) is deposited on to an inner wall of the vacuum processing chamber, electrodes, and the like. Such a residual reaction product deteriorates the etching characteristics. That is, a side etching process is advanced, and the etching rate of polycrystalline silicon is fluctuated, so that reproducibility of etching cannot be obtained. Also, when air is introduced into the vacuum processing chamber, the water component thereof is reacted with the residual reaction product to generate strong hydrogen bromide gas. Therefore, it is necessary to clean the residual reaction product in the vacuum chamber.

In the prior art, no method for cleaning the residual reaction product of Si_xBr_y has been suggested yet. Therefore, the residual reaction product of $Si_x Br_y$ is manually scraped out. As a result, since the vacuum processing chamber cannot be successively operated, the efficiency is reduced. Also, this manual scraping operation is disadvantageous in respect of the safety of the

operators. Further, since the vacuum chamber and its peripheral equipment may be rusted, the manufacturing yield of semiconductor devices by using the vacuum processing chamber is reduced.

Note that JP-A-SHO61-250185 discloses a method for cleaning a residual reaction product of silicon chloride (Si_xCl_y) from a vacuum processing chamber. In JP-A-SHO61-250185, oxidative gas is introduced into the vacuum processing chamber and plasma is excited therein. Then, after the plasma oxidative gas is exhausted, fluoride gas is introduced into the vacuum processing chamber and plasma is excited therein. Even if this cleaning method is applied to the residual reaction product of Si_xBr_y, it is impossible to homogeneously and effectively convert Si_xBr_y into silicon oxide. As a result, since Si_xBr_y hardly reacts with fluoride gas, Si_xBr_y is still left in the vacuum processing chamber.

Also, in JP-A-HEI2-138472, which discloses a method for cleaning residual silicon deposit in a vacuum processing chamber, use is made of plasma of a gas mixture of SF_6, oxygen containing gas and rare gas. However, it is impossible to apply this cleaning method to the residual reaction product of Si_xBr_y.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a new method for cleaning a vacuum processing chamber to remove residual reaction products such as Si_xBr_y.

According to the present invention, in a method for cleaning a vacuum process chamber of a dry etching apparatus, oxidative gas including rare gas is introduced into the vacuum process chamber and plasma is excited therein. Then, after the plasma oxidative gas is exhausted, fluoride gas is introduced into the vacuum processing chamber and plasma is excited therein. As a result, the bromine group of Si_xBr_y is replaced by oxygen in an oxidative plasma gas, to thereby create

silicon oxide (SiO_2). In this case, the oxidative plasma gas is diluted by the rare gas, so that the oxidative plasma gas is homogeneously distributed within the vacuum processing chamber. Also, light emitted from the plasma of rare gas which has a line spectrum promotes the above-mentioned replacement reaction. Thus, Si_xBr_y is completely converted into silicon oxide under an oxidative plasma gas including rare gas, and therefore, the silicon oxide is removed by the fluoride plasma gas.

BRIEF DESCRIPTION OF THE DRAWING

The present invention will be more clearly understood from the description as set forth below, with reference to the accompanying drawing, wherein:

Fig. 1 is a cross-sectional view illustrating a vacuum processing chamber to which an embodiment of the method for cleaning a residual reaction product of Si_xBr_y is applied.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In Fig. 1, reference numeral 1 designates a vacuum processing chamber of a dry etching apparatus. Provided in the vacuum processing chamber 1 are gas inlets 2a and 2b and a gas outlet 3. The gas outlet 3 leads to a vacuum exhaust system 4.

A semiconductor substrate 5 is mounted on a substrate holder 6 which also serves as an electrode which is connected to a high frequency power supply source 7. In this case, assume that a polycrystalline silicon layer is deposited on the semiconductor substrate 5 by a chemical vapor deposition (CVD) process in advance.

Also, reference numeral 8 designates a ground electrode. Note that the vacuum processing chamber 1 is also grounded.

A dry etching process for the polycrystalline silicon layer is now explained. That is, hydrogen bromide (HBr) is introduced via the gas inlet 2a into the vacuum

processing chamber 1, and the high frequency power supply source 7 is turned ON to excite plasma therein. As a result, bromine radicals and bromine ions are reacted with the polycrystalline silicon layer, and therefore, the polycrystalline silicon layer is converted into silicon bromide which is exhausted via the gas outlet 3 from the vacuum processing chamber 1. That is, the polycrystalline silicon is etched. In this case, silicon bromide is deposited onto an inner wall 1a of the vacuum processing chamber 1, the substrate holder 5, the ground electrode 8, and the like.

A cleaning method for the residual silicon bromide is explained next in detail.

First, oxygen including, for example, helium (He) gas is introduced via the gas inlet 2b into the vacuum processing chamber 1, and the high frequency power supply source 7 is turned ON to excite plasma therein. The conditions are preferably as follows:

the mixture ratio of He to O_2: 3:7
gas stream amount: 15 to 300 sccm
gas pressure: 80 to 300 mTorr
frequency of the source 7: 13.56 MHz
power of the source 7: 100 to 1000 W.

As a result, the following reaction occurs:

$$SiBr_4 + He + O_2 \rightarrow SiO_2 + He\uparrow + 2Br_2\uparrow \cdots (1)$$

Note that, if the mixture ratio of He to O_2 is smaller than approximately 10 percent, the strength of light emitted from the plasma helium may be so weak as to not excite the bromine group of $SiBr_4$. On the other hand, if the mixture ratio of He to O_2 is larger than approximately 90 percent, the oxygen is generally so short as to not promote the above-reaction (1). Therefore, the mixture ratio of rare gas such as helium to oxygen is preferably within a range of approximately 10 to 90 percent.

Next, the introduction of the oxidative gas including helium is stopped, and an exhaust operation is performed upon the vacuum processing chamber 1.

Next, fluoride'gas such as sulfur hexafluoride gas is introduced via the gas inlet 2b into the vacuum processing chamber 1, and the high frequency power supply source 7 is turned ON to excite plasma therein. The conditious are preferably as follows:

gas stream amount : 15 to 300 sccm
gas pressure: 80 to 300 mTorr
frequency of the source 7: 13.56 MHz
power of the source 7: 100 to 1000 W.

As a result, the following reaction occurs:

$$SiO_2 + SF_6 \rightarrow SiF_4\uparrow + SF_2\uparrow + O_2\uparrow \cdots \quad (2)$$

Finally, the introduction of the fluoride gas is stopped, and an exhaust operation is performed upon for the vacuum processing chamber 1.

According to the experiments carried out by the inventor, after the above-described cleaning method is carried out, no smell of hydrogen bromide has been found, and no residual reaction product (Si_xBr_y) has been found in the inner wall of the vacuum processing chamber 1. A time required for cleaning the vacuum processing chamber and the electrodes was about 30 minutes, while a time required for manually scraping the residual reaction product(Si_xBr_y) was about 6 hours.

In the above-described embodiment, although helium is used as the rare gas, other rare gases such as neon (Ne), argon (Ar) and the like can be used. Also, water (H_2O), hydrogen peroxide (H_2O_2) or ozone (O_3) can be used as oxidative gas instead of oxygen. Further, carbon tetrafluoride (CF_4), nitrogen trifluoride (NF_3), or their mixture gas can be used as fluoride gas instead of SF_6.

As explained hereinbefore, according to the present invention, the residual reaction product(Si_x Br_y) can be homogeneously and effectively removed from the vacuum processing chamber, the electrodes, and the like.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The appended abstract as filed herewith is included in the specification by reference.

CLAIMS

1. A method for cleaning a vacuum processing chamber for processing a silicon substrate with bromide gas, comprising the steps of:

introducing oxidative gas including rare gas into said vacuum processing chamber to excite plasma in said oxidative gas;

exhausting said oxidative gas from said vacuum processing chamber; and

introducing fluoride gas into said vacuum processing gas to excite plasma in said fluoride gas, after exhausting said oxidative gas.

2. A method as set forth in claim 1, wherein said oxidative gas is one of O_2 gas, H_2O gas, H_2O_2 gas, and O_3 gas.

3. A method as set forth in claim 1 or claim 2, wherein the mixture ratio of rare gas in said oxidative gas is approximately 10 to 90 percent, preferably 10 to 80 percent.

4. A method as set forth in any one of claims 1 to 3, wherein said rare gas is one of He gas, Ne gas and Ar gas.

5. A method as set forth in any one of claims 1 to 4, wherein said fluoride gas is one of NF_3 gas, C_2F_6 gas, CF_4 gas and SF_6 gas.

8

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9519924.6
Relevant Technical Fields (i) UK Cl (Ed.N) B6J (JMB1, JMB2, JMB3, JMX, JMY) (ii) Int Cl (Ed.6) C23C 16/44, C23G 5/00	Search Examiner R J MIRAMS Date of completion of Search 21 DECEMBER 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI, CLAIMS	Documents considered relevant following a search in respect of Claims :- 1 TO 5

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	WPI Abstract Accession No. 86-335260/51 and JP 61250185 A (NICHIDEN ANELVA) see Abstract	

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

Fig. 1